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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Multi-Layered Structural Member

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ABSTRACT OF THE DISCLOSURE

The invention describes a multi-layered structural member (1) comprising a core (4) of a foamed plastic (10) of primary material and, if required with flocks (5, 6, 7) of foamed plastic (12, 13) connected thereto. At least on one of the surfaces of the core (4), a covering layer (2, 3) with a supporting body (15) of fibres or respectively threads is arranged and connected thereto in a frictional and/or formlocking manner. The fibres or respectively threads of the supporting body (15) are embedded in a layer (16) of thermoplastic synthetic material (17) which forms the covering layer (2, 3) and by means of the latter are formed onto the core (4) and are connected thereto in a frictional or respectively formlocking manner.

Fig. 7

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MULTI-LAYERED STRUCTURAL MEMBER

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to a multi-layered structural member as described in the generic term of Claim 1, and also to a method and a device for the production of a multi-layered structural member as described in the generic term of Claim 24 and 32.

Description of the Prior Art

A method for the production of sandwich elements is already known- according to EP-B1 0 266 224. This sandwich element consists of a surface layer, for example an interlacing or knitted fabric of polyester, viscose, glass fibres or any combination thereof, a first reinforcement layer arranged behind it and a thermally deformed, cell-shaped core material, a second reinforcement layer and a top layer. The bonding of the individual layers, in particular the surface layer with the core material, occurs by means of an adhesive, whereby the adhesive layer is simultaneously inserted in the first reinforcement layer and the other reinforcement layer is secured to the core element by means of a further adhesive layer. The production of this sandwich element takes place by a continuous production process wherein the individual layers are partially pulled off a roller and guided through the processing machines and wherein the forming and also the activation of the individual adhesive layers in the sandwich component takes place by

means of a form tool and an embossing punch and if required, a cutting tool during the continuous flow through the production path. This way, the production of such sandwich components can be accelerated and simplified, however, the achieved strengths in the vicinity of the covering layers is not sufficient in many regions.

SUMMARY OF THE INVENTION

It is the object of the present invention to create a multi-layered structural member which can also be provided with enough inherent rigid covering layers and which can again be split up into individual material layers after use.

This object of the invention is solved by the features described in the characterizing clause of Claim 1. The surprising, unforeseeable advantage of this solution lies in that a thermoplastic synthetic material is used which can be liquefied at a temperature range wherein the core-forming foamed plastic layer having a low specific gravity does not lose its strength or respectively wherein the cell structure of such foamed plastics breaks down. This way, it is possible to create a soft, elastic and resilient core of foamed plastics, in particular also of recycling material, which, on the other hand can be tightly connected with a very hard, load-bearing supporting layer, the thickness of which can be adjusted in any way possible. Said core can be reinforced at the same time to a sufficient level of strength by means of the inserted supporting body. Consequently, it is possible to create a covering layer with high bearing strength in a fastening and forming

on process. The further advantage, however, lies in the fact that by using the thermoplastic synthetic material when reprocessing or reworking plastic arisings, the separation of the supporting body and the covering layer from the layer of thermoplastic synthetic material can be achieved in a simple manner by heating the covering layers to an appropriately high temperature and by re-liquefying the thermoplastic synthetic material. This way, a possibility is created that first, the supporting body is completely removed from the core material which in most cases consists of plastic material, whereby for example, the thermoplastic synthetic material is lifted off before it is completely liquefied, i.e. in a toughened plastic state, whereafter, when the thermoplastic synthetic material is heated up further and completely liquefied, said material can also be completely removed from the supporting body and processed for re-use. Thus, in the sense of the planned separation of recycling plastics, it is now possible to completely separate from one another the individual layers of a sandwich component, which achieves a simplified waste disposal and in particular, an essentially easier reutilization of recycling material. In addition, due to a particular structure of such a structural member, two covering layers can be created which are connected to one another by an elastically deformable and preferably readjustable core, and which are advantageously suitable for the damping of sound waves or impact movements, such as structure-borne noise as it occurs in motor vehicles, but of course also for airborne sound. This is possible because in the region of one of the two covering layers, the structural member can be secured to fastening elements, for example to a body of a vehicle, whereas the other covering layer facing towards the passenger compartment is positioned in a free-floating manner which dampens the structure-borne noise transmission from the vehicle body into the inner room of the vehicle. With a suita-

ble design of the covering layer facing towards the passenger compartment, it is thereby possible that said layer has enough strength to prevent any destruction during normal use and, on the other hand, gives still enough impact protection with adjustable limits, which , in case of an accident, prevents to a high degree an injury to the user. By making it possible that further top layers are arranged - besides the covering layers - of different materials such as for example plastic foils, textiles and the like, it is also easily possible by selecting the appropriate materials to achieve sufficient damping of airborne sound through the construction of the structural element.

Another object of the invention is also advantageous because depending on the recycling material used during the waste disposal of recycling materials, the specific gravity and the damping behaviour as well as the strength of the structural member can be easily established.

By a further development, in connection with the application of the covering layer to the structural member, a processing of recycling plastics provided with hard or semi-hard coatings is made possible since the hard components of the coatings are not pushing through the covering layers and consequently, there is no surface deterioration.

A tight connection of the recycling materials or the flocks of foamed plastic is achieved by a further object of the invention, whereby furthermore, in particular when using flocks of recycling material, the portion of the primary material for the production of the core can be held at a minimum.

By a further object of the invention a tight embedding of the flocks into the core, and in spite of it, a slight proportional increase of the specific gravity is achieved advantageously.

Another object of the invention is also advantageous because besides sufficient strength, a satisfactory elasticity can be achieved to reduce vibration between the two covering layers.

A different object of the invention allows for the production of a sufficiently tight cell structure in order to embed the individual flocks of foamed plastic in the supporting structure so that the carrying function of the core as a connecting means between the two covering layers can also be used at higher stresses.

By another object of the invention stresses occurring during use can be counteracted in a simple manner and by selecting the elastic properties of the noise damping values of the core, can be easily adapted to different cases of use.

By adapting the thermoplastic according to another object of the invention, a universal matching of the structural members to various different cases of use can be achieved.

The wide variety of configuration possibilities of the covering layer, which permit a universal use of the structural members produced in such a way, in different

areas of noise damping, for example the inside facing of vehicles, in the construction industry and the like, are shown by the features described in a further object of the invention.

By a further development of an object of the invention, such structural members can also be used in highly stressed regions, for example in regions wherein they are subjected to higher impact and frictional stresses.

A different object of the invention is also advantageous because thereby the supporting body can be coated with the required materials, which can be easily handled due to the powder used during the production process, and for example can also be processed without adhering to the roller so that the thermoplastic synthetic material can only be liquefied when it is heated up accordingly, which ensures an even distribution over the supporting body. It is also recommended to arrange a foil of thermoplastic synthetic material, which is softened accordingly or which is plasticized or liquefied, since this way, the production of the structural member in accordance with the invention is greatly simplified.

However, an object of the invention is also possible wherein the energy costs for the liquefaction of the thermoplastic material are kept lower, or respectively allow for the use of various different raw materials for this thermoplastic synthetic material.

By a further development of an object of the invention, good adhesion of

the thermoplastic layer to the supporting body is achieved whereby an intensive and high-strength connection between the supporting body and the thermoplastic layer can be achieved.

By still another object of the invention it is possible to use the thermoplastic synthetic material for the shaping or embedding of the supporting body without exceeding the temperatures which would lead to a disadvantageous change or respectively cracking or an oozing out of oil of the cell structure of the core.

Furthermore, by a different development of an object of the invention, a disposal of such structural members is relatively easy, since the structure of the core, even if the latter consists of foamed plastics, is not destroyed during the separation and thereby, it is possible to reuse the foamed plastics as flocks for the production of a new structural element after said plastics have been torn up and reprocessed.

Moreover, another object of the invention is also advantageous since the thermoplastic synthetic material, besides the production of a sufficiently strong covering layer, allows also for an all-over connection and application of a top layer without the need of applying an additional adhesive layer.

A different object of the invention is also advantageous, because thereby fastening means are created which allow for greater tearing strengths or respectively an improved introduction of force than the use of supporting elements as fastening elements.

A further development of an object of the invention proved also very advantageous, because thereby before covering layers are applied, reinforcement elements can be mounted on the already prefabricated structural members in the different surface regions where they are needed.

Advantageous further developments for the supporting element are described in the features of another object of the invention, because thereby a batt-like structure can be achieved, which can be easily produced and processed, and in spite of the loose linking of the long threads, enough stiffening can be achieved to form a supporting body. Thereby, a good connection between the top layers and the foamed plastic of the core can also be achieved.

Furthermore, the invention encompasses also a method for the production of a multi-layered structural member as described in the generic term of Claim 24.

This method is characterized by the features in the characterizing clause of Claim 24. Due to this type of production, it is now possible to carry out in a simple way a cycle production for large series of such structural members, whereby the handling for the production of the structural members can be greatly simplified for the individual components. In addition, some of the materials used can now be processed directly from the roller, and often an application of liquid components, in particular adhesives admixed with solvents and the like, is no longer required. In addition, structural members for various different requirements can be produced according to the same system with very few

changes during the course of production.

By the measures according to another object of the invention, it is achieved that also a three-dimensional shaping of the member can take place by applying the temperature, which is needed to liquefy the thermoplastic synthetic material, whereby it is also possible to ensure a different three-dimensional shape by means of a differently strong compression of the core, in particular of foamed plastic elements in the core, without that the cell structure of the core has to be thermally deformed or cracked since only by pressing the elastic core materials, the latter are proverbially frozen in the prestressed state due to the solidification of the thermoplastic covering layer, and thereby their elasticity properties are not destroyed or eliminated in spite of the higher density and specific gravity. Consequently, the damping properties of such structural members, in particular during noise damping, are very good.

An even greater three-dimensional deformation and, if required, partial strengthening of the cell structure of the core can be achieved by proceeding according to another object of the invention. In individual cases it is thereby also possible to get by with low forces of pressure for the spatial deformation of structural members.

The measures according to another object of the invention permit a strengthening of the structural member, for example in fastening regions, so that these members receive almost the structure of a full material component with the advantages of a sandwich construction.

By using a plastic according to another object of the invention and the appropriate heating, it is possible to use a range of different materials for the core, which do not lose their mechanical or chemical properties.

By measures according to a further object of the invention, a separate waste disposal of the individual coatings or layers of the structural member is ensured in a simple manner.

By a different object of the invention, the thermoplastic synthetic material can be almost completely removed from the supporting body.

However, it is also advantageous to proceed according to another object of the invention, since in one processing step with a supporting layer required for the mechanical properties of the structural member, the connection can be made simultaneously to the different top layers.

Furthermore, the invention comprises a device as described in the generic term of Claim 32.

This device is characterized by the features described in the characterizing clause of Claim 32. Thereby, it is advantageous to create an in-line method, which, especially when the same supporting body is used for the two covering layers, is enough to get by with a manufacturing installation for the supply of the top layers and the introduction

of the thermoplastic synthetic material for the production of the structural member. Thereby, it is also possible that after the covering layer has been supplied, several form tools can be provided, which can be alternately fed from a continuing feeding installation whereby the output of such a manufacturing device can be greatly increased.

Finally, an embodiment of the device according to another object of the invention is also advantageous, because thereby the individual covering layers can be held in a precise position during the forming and deforming process and during curing, whereby a displacement of the vacuum slots can be prevented in that after the compression and positioning of the covering layers and the core in the mould by means of these vacuum slots, if required, air for cooling can be supplied for the rapid solidification of the shaped part.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained hereinafter in further detail by means of the example embodiments illustrated in the drawings, in which:

FIG. 1 is a view, in perspective, in section and a greatly enlarged, diagrammatic representation of a multi-layered structural member in accordance with the invention having a core of a foamed plastic element;

FIG. 2 is a side view and a simplified, diagrammatic representation of the structural member according to FIG. 1 spatially deformed;

FIG. 3 is a front view, in section and a simplified, diagrammatic representation of another multi-layered structural member in accordance with the invention;

FIG. 4 is a side view, in section and a simplified, diagrammatic representation of another variant of an embodiment of a multi-layered structural member in accordance with the invention;

FIG. 5 is a side view and a simplified, diagrammatic representation of a device for the production of a multi-layered structural member in accordance with the invention;

FIG. 6 is a simplified, diagrammatic representation, in perspective, of another embodiment of a supporting element;

FIG. 7 is a view, in perspective, in section and a greatly enlarged, diagrammatic representation of a multi-layered structural member in accordancee with the invention having a core of foamed plastic and the supporting element according to FIG. 6.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 hows a multi-layered structural member 1, which consists of two covering layers 2, 3 between of which a core 4 is arranged. But it is of course also possible to arrange only one of the two covering layers 2, 3 on the core 4.

The core 4 consists of flocks 5, 6, 7 of hard, semi-hard and/or soft foams, if required, with backs of different materials 8, 9, which, by means of a foamed plastic 10, for example polyurethane or polyethylene foam, polyester foam or the like of primary material, which may have a soft and/or semi-hard and/or hard consistence, are connected with a single plate 11 or a block, from which the single plates 11 preferably can be produced by cutting. Between 70% and 90%, preferably 85% of the volume of this core 4 are formed by the flocks, 5, 6, 7, of foamed plastic 12, 13 and 10% to 20% of the weight are formed by foamed plastic 10 of primary material. The flocks 5, 6, 7 of foamed plastic 12, 13 have a specific gravity between 20 kg/m^3 and 250 kg/m^3 , preferably 50 kg/m^3 to 150 kg/m^3 . The specific gravity of a foamed plastic 10 produced from primary material is between 700 kg/m^3 and 1 300 kg/m^3 , preferably between 800 kg/m^3 and 1 200 kg/m^3, and is preferably semi-rigid or semi-hard. The core 4 is formed by a single plate 11 having a predetermined thickness 14, which, preferably is produced by the cutting up of a foamed material block. It is, however, of course also possible to use the single plate 11 only from primary material of the foamed plastic 10 or respectively instead of the flocks 5, 6, 7 of foamed plastic 12, 13 to use any other materials such as textiles, cork, wood, natural and synthetic substances.

The two covering layers 2, 3 are formed by a fibre or respectively thread-shaped supporting body 15 of natural and/or synthetic materials, for example a net, knitted fabric, fabric, braiding, lattice or batt of fibres or threads of glass, metal, kevlar, graphite or textiles, which is embedded in a layer 16 of thermoplastic synthetic material 17 which is formed onto the core 4. The thermoplastic synthetic material 17 is reinforced by the fibre or thread-shaped supporting body 15 and simultaneously takes over the frictional and/or formlocking connection between the supporting body 15 and the core 4. This layer 16 of thermoplastic synthetic material 17 can also be formed for example by an entanglement of individual fibres or threads, which are melting into one another under pressure and/or temperature stress and are thus embedding the supporting body 15.

Furthermore, as it is indicated schematically in the region of the covering layer 2, it is also possible by means of the layer 16 of the thermoplastic synthetic material 17, such as for example polypropylene, to form on simultaneously a top layer 18, for example a material, a knitted fabric, fabric, a carpet or a batt. Particularly advantageous proved a polymethane foil or plate or a cotton batt, which, in particular improves the noise damping properties. But polyurethane may also be used as material for the supporting body 15.

Thus, the layer 16 of thermoplastic synthetic material 17 does not only form a supporting body 15 which is reinforced by a bearing element 19 but at the same time forms also the connection layer between the core 4, the supporting body 15 and if required, the further top layer 18.

A particular advantage of a structural member 1 constructed in such a way however, lies in the fact that at least one hard and resistant covering layer 2 or the bearing element 19 thereof, and if required, the top layer 18 is spaced apart from the further covering layer 3 or respectively the bearing element 20 thereof or a top layer 21 resiliently damped by the flocks 5, 6, 7 of foamed plastic 12, 13 of the core 4. This way, the two covering layers 2, 3 can be swinging independently of one another, and thereby good noise damping can be achieved, as it is used mainly in the car industry or for room dividing walls or the like, with the special advantage for example for structure-borne noise damping. To remove the synthetic material 17 of the supporting element from the supporting body 15, it is for example possible to heat the said plastic up to a temperature of 200°C and thereafter, to suck it off the supporting body 15.

The advantage lies in particular in the fact that by the resistant covering layers 2, 3 and the use of the layer 16 of thermoplastic synthetic material 17, which is reinforced by the supporting body 15, to achieve a high surface and/or edge pressure strength and on the other hand, that the total weight of such structural members 1 can be kept at a minimum by the low specific gravity of the core 4.

Even if in the course of the heating during the forming on of the layer 16 of thermoplastic synthetic material 17 to the core 4, for example in the surface layers of the latter, it should come to a softening of a cell structure 22 or a deformation or compression of the cell structure 22, the total specific gravity of the core 4 is only slightly modified, so that the advantages of the direction connection by this layer 16 of thermopla-

stic synthetic material 17 are exceeding to a great extent the slight disadvantage of an eventual increase in specific gravity of the core 4. This may take place for example through thermal cracking.

For this thermoplastic synthetic material 17 it is of course possible to use a variety of different materials such as ethylene, polyethylene, polyamide, polypropylene, polystyrene, ABS, PVC, polyimide or any other thermoplastic which at temperatures of at least 120°C to 180°C, preferably 170°C is in a toughened plastic state or liquefied. The manner, how the thermoplastic synthetic material 17 is applied to the supporting body 15 or respectively the core 4, can be chosen freely within the scope of the invention. It can either be applied in the shape of a paste or a granulate onto the supporting body 15, which, preferably rolls off a roller, or can be sprayed on in an almost liquid state, which adheres only slightly at room temperature. However, it is also possible to apply it to the supporting body 15 as a powder or as a kind of precoating or as a foil or batt on one side or both sides of the supporting body 15, or respectively to embed the latter into the synthetic material 17.

FIG. 2 shows a multi-layered structural member 1, which, at least in one plane is spatially deformed. This structural member 1 consists of a core 4, similar to the one described in FIG. 1, which is produced according to the embodiments in FIG. 1, on the surfaces of which, which are facing away from one another, bearing elements 19, 20 are arranged by means of which the core 4 is formed on with additional top layers 18 or respectively 21. The bearing elements 19, 20 consist each of a supporting body 15, which

can be formed by a net, knitted fabric, fabric, lattice, threads, fibres or a batt or the like of the materials described hereabove, which is embedded in a layer 16 of thermoplastic synthetic material 17. As it can be seen further from the illustration in FIG. 2, a density of the core 4 or respectively the flocks 5, 6, 7 over the entire cross-section of the core 4 is the same in spite of the spatial displacement 23 which is formed by displacing a surface part 24 with respect to an adjacent surface part 25 about a depth 26.

Such an embodiment of the structural member 1 is possible by the fact that the deformation of the core 4 and also of the two bearing elements 19, 20 takes place when the thermoplastic synthetic material 17 of the layer 16 is plasticizing, i.e. is in a plastic or liquefied state, whereupon the shape of the structural member 1 is kept up by corresponding moulding surfaces associated therewith until the layer 16 of thermoplastic synthetic material 17 is cooled to such an extent that it shows its own stability and thereby is holding the core 4 in the region of the passage 23 in the position shown in FIG. 2.

By this type of construction of the structural members 1 or the method for their production, it is therefore possible to produce structural members 1 which have a variety of different three-dimensional shapes, for example also spherically curved parts or free moulding surfaces, whereby this process can take place without a thermal deformation of the cell structure 22, for example by heating up the core 4 accordingly and thereby, the elastic properties of the core 4 can be kept up in a simple manner, in particular with respect to noise damping or a protection against an impact achieved therefrom.

FIG. 3 shows an embodiment wherein the structural member 1 is formed by a body with free moulding surfaces. This way, the latter is for example deformed in all three spatial directions and in the region of the two surfaces of the core 4 has bearing elements 19, 20, which can be formed according to the embodiments shown in FIGS. 1 and 2.

In this case, top layers 18 or respectively 21 are also arranged on the two bearing elements 19, 20. Thereby, the top layer 18 can be formed for example by a polyurethane foil or any other facing surfaces in vehicles, for example by a surface layer used for dashboards, whereas the top layer 21 can be formed by a polymethane foil or plate or a cotton batt, in order to dampen for example the sound waves from a motor 28, which are indicated schematically by arrows 27, so that the entry of sound into the inner chamber of a vehicle is reduced, as indicated symbolically by smaller arrows 29. The structural member 1, which, for example, may be formed by a dashboard, moreover is secured to a vehicle frame 30 by fastening means 31, such as screws or rivets.

This exemplary embodiment shows as a variant that if the tearing strength of a fastening means 31 in the bearing elements 19, 20 is not enough to secure the structural member 1, a reinforcement element 32 for example may be arranged between the bearing elements 19 and/or 20. Preferably, this reinforcement element 32 is secured and held to the bearing element 20 or respectively by means of the latter to the core 4 via the adhesive force of the synthetic material 17 forming the layer 16.

In this connection it is of course also possible to make provision for such a reinforcement element 32 at any location of the surface of the core 4 facing towards the bearing element 19 and/or 20. It is of course also possible to create the core 4 for example by two plates and to arrange between the latter an additional reinforcement element 32. Another possibility is that during the compression of the structural member 1 too high a pressure is exerted so that a reinforcement element 32 which has been laid onto the surface of the core 4 is pressed into the core 4 due to the compression of the foam struction to such an extent that the bearing element 19 and/or 20 is running over it in a plane. This local compression of the core 4 is kept up after the solidification of the thermoplastic synthetic material 17 by its inherent strength, so that there is no further thermal compression through a deformation of the cell structure or respectively a breakdown of the cell structure.

FIG. 4 shows that simultaneously with the compression of the structural member 1 due to the spatial deformation of the bearing elements 19, 20, a density of the core 4 in regions 33, 34 and 35 arranged randomly next to each other, and a thickness 36, 37 or 38 can be differing from one another.

It is interesting in this embodiment of the structural member 1 in accordance with the invention or in the method for the production of this structural member 1, that these different thicknesses 36 to 38 are not produced by a thermal or dynamic composition through a breakdown of the cell structure 22, but only by using the elastic properties of the flocks, 5, 6, 7, which in most cases consist of foamed plastic 12, 13, i.e. due to the

elastic compression of the latter and also the elastic deformation of the cell structure 22 situated therebetween, whereby in these regions 34 and 35, which are more compressed, the individual flocks 5, 6, 7 have a smaller outer volume and are more tightly positioned. This way, a greater specific gravity and thereby greater stiffness of the core 4 can be obtained in these regions so that for example the tearing forces can be stronger for the fastening means 31, which can be guided through the structural member 1 by a bore 39. Thereby it is also possible by a purposeful compression or respectively modification of the thickness of a core 4, which initially had an even thickness, to create differently stiffened zones in the region of a technical structural member, for example a facing element or the like.

FIG. 5 shows a device 40 for the production of a structural member 1 in a simplified, diagrammatic representation.

Thereby the production of the structural member 1 takes place in such a way that in a foaming mould 41 either plates 42 for the core 4 are produced individually or , as it is also indicated schematically, a foamed block is produced which is divided up into individual plates 42 by a cutting device 44. The foaming mould is fed with primary material,for example from a receptacle 45 and from a raw material tank 46 with flocks 5, 6, 7 of different types of foams or respectively materials having a different hardness or respectively stiffness such as hard, semi-hard or respectively soft foams, whereby in this case it is a matter of so-called recycling foams or recycling materials which can also be provided with corresponding parts of foils or coatings. The primary material, which can

also be extracted by a recycling process can be in a liquid state for the production of the cell structure of a mixing device 47 and can be supplied via corresponding dosing elements 48. In this mixing device 47, the flocks 5, 6, 7 are mixed with liquid raw material 49 for the cell structure 22 and thereafter are filled into a mould cavity 50.

By the supply of a reaction agent, for example with a pump 51, perhaps a vapour, in particular a dry vapour of between 120°C and 160°C, the liquid raw material 49 is reacting due to a heat exchanger 52 and is blown up for example by released gases, so that a cell structure, in particular the cell structure 22 is build up by closed or open or respectively partially closed or open cells.

After a drying phase, which follows the reaction phase and during which only dry air is blown through, the foamed block 43 can be taken out of the foaming mould 41.

The production of the structural member 1, for example in an illustrated phase sequence takes place in such a manner that in a first workstation 53 the supporting body 15 is rolled off a roller 54 and put onto a rotating belt conveyer 55, for example with a Teflon band or a band coated with a lubricant. The supporting body 15 is preferably coated with a paste-like and/or pulverulent thermoplastic synthetic material 17. However, it is also possible that immediately in front of a heating device 56 the thermoplastic synthetic material 17 is applied in liquid or paste-like state by means of a coating device 57. When passing through the heating device 56, the thermoplastic synthetic material 17 is

softened to such an extent that it shows its full adhesive properties and can be displaced at least in an elastoplastic manner, i.e. it shows a plastic or liquid or paste-like consistence.

A front end 58 of the supporting body 15 is gripped by a gripper 59 of a handling device 60 and is pulled forward to a further conveyer 62 by means of a conveying belt 61. This way, for example it is possible to grip the supporting body 15 with a further gripper 59. In a cutting process the supportingbody 15 is separated at a desired length 63 of the plate 42 by means of a cutting device 64 and is put directly onto the conveying belt 61 of the conveyer 62 for exampleby means of the two grippers 59 serving as bearing element 20.

Thereafter, by means of a further handling device 60, which is not shown in detail, or respectively by using the same grippers 59, a plate 42 is put onto the bearing element 20 and thereafter, as in a manner described hereabove, a supporting body 15 is applied again to the upper side of this plate 42. According to the different variants of an embodiment described in FIGS. 1 to 4, it is of course also possible to apply a top layer 18, 21 to one or both surfaces of the supporting body 15, in that for example, the top layer 21 is applied before the bearing element 20 is installed and the top layer 18 after the bearing element 19 has been put onto the plate 42 or respectively the core 4.

Thereafter, the conveyer 62, for example along a guideway 65 can be transported from a layer positioning station 66 into a preforming station 67 or respectively in a layer positioning station for the top layer 18 or respectively 21. In this preforming

station 67 for example, a top layer 18 which has been unrolled from a roller 68 can be applied to the supporting body 15 and can be roughly positioned by a corresponding pressure in order to adhere to the latter.

Then the prefabricated semi-finished product can be put into a shaping press 69.

By closing or respectively by putting a male mould 70 onto a female mould 71 by means of pressure drives 72, the structural member 1 can be deformed into a spatial form drawn schematically by full lines, whereby the structural member 1 is held between the male mould 70 and the female mould 71 until the thermoplastic synthetic material 17 of the layer 16 in which the supporting body 15 is embedded, is solidified or cooled to the extent that the dimensional stability is enough to hold or secure the core 4 or respectively the flocks 5, 6, 7 contained therein with the cell structure 22 pressed into the desired spatial form. This temperature range up to which the structural member 1 must be kept in the shaping press 69 depends on the synthetic material 17 used or respetively also on the readjusting forces which developed during the deformation of the core 4 and are inside the latter, so that the desired spatial form can also be maintained after the structural member 1 is cooled completely.

Downstream of this shaping press 69 a punching station 73 must be arranged, into which the prefabricated structural member 1 - as indicated by broken lines - is introduced and cut at its periphery to the desired final shape and, if required, which is also

possible within the scope of the invention - is brought into the desired final spatial form by an additional thermal transformation.

In the course of the production of the structural member 1 it is of course also possible, that for example in the laminating station 66 or in the preforming station 67 between the core 4 or respectively the bearing element 20 and/or a top layer 18 or respectively 21, a reinforcement element 32 is positioned or introduced. It is of course also possible to produce the bearing element 19 or 20 from several other layers than described to introduce by means of the supporting body 15 under adhesion with the synthetic material 17 of the layer 16 a further foil in order to achieve the required bending or respectively deformation or strengthening properties on the mould surface of the structural member 1.

Of course, it is a matter of possible embodiment and arrangement variants in the described device 40 and the method described in connection with this device 40, and the device 40 as well as the method can be changed in any way possible by the expert within the scope of knowledge at the state of the art as long as the required properties of the structural member 1 are achieved during production.

FIGS. 6 and 7 show further embodiments of the multi-layered structural member 1, in which the same reference numbers are used for the same parts.

Thus, FIG. 6 shows another embodiment of the bearing element19 before

it is connected with a core 4, whereby the bearing element 19 is formed as a batt 74 in this condition. This batt 74 consists, on the one hand, of an entanglement of individual threads 75, which preferably are formed by the thermoplastic synthetic material 17 such as for example polypropylene, polyethylene, polyamide, polystyrene, ABS, PVC, polyimide, and on the other hand, of insert threads 76 which are longer and which form the supporting body 15. The selection of the material of the threads 75 and the insert threads 76 depends on the required conditions of use and can be chosen freely or respectively can be combined among themselves in any way possible. The threads 75, on their part form their own fibre layer 77, into which the individual insert threads 76 of the supporting body 15 are loosely inserted during the production process of said fibre layer. This way, a batt 74 which is easy to produce, is achieved in its overall structure, which can be simply adapted in its dimensions to any required conditions of use. The mixing ration of the threads 75 and the insert threads 76 can be 70% to 30% for example. Furthermore, an individual thread 75 shows that it may consists of individualfibres or respectively threads. The same is also applicable for the embodiment of the insert thread 76.

It is of course also possible to produce the threads 75 for the fibre layer 77 from polyamides. It is further recommended for the threads 75 of the fibre layer 77 , especially if they are of polypropylene or aromatic amide or polyamide, that they present a titre, i.e. a weight/length ratio of 2 dtex to 8 dtex, preferably 3.5 dtex. Since the fibre layer 77 is produced in that the individual fibres or respectively threads 75 adhere to one another through needle bonding or interlocking and in some particular cases through thermal linking, that is to say htrough simultaneous action of pressure and temperature, or

respectively are secured to the loose mat forming the fibre layer 77, it is advantageous, especially if a high tensile strength and tearing strength for example, in particular at a low specific gravity of such a batt, should be achieved, to use the right length of the fibres or respectively threads 75 for the production of the fibre layer 77. Thereby, particular a length of the threads 75 between 5 mm and 50 mm proved advantageous.

Thereby, it must be taken into account that during production of this batt 74 or respectively the fibre layer 77, the fibres or threads 75 and/or insert threads 76, for exampleof cotton, wool, flax or also of polyamide, polyester, PVC, PP, PE or Nylon, or respectively aromatic amides or the like can be applied as loose bulk material , for example to a supporting layer serving as conveying belt. During the forward movement of the bulk material on this supporting layer, this entanglement of fibres or respectively threads 75 and/or insert threads 76 mostly needle-punched or interlocked by hook-shaped needles in order to form a continuous body which is interconnected in itself. This connection is independent of the fact if the supporting layer is connected with the fibre layer by the fibres or respectively threads 75 and/or insert threads 76, and also if the supporting band is a continuously revolving machine part. Here, it should also be mentioned that depending on the conditions of use any combination of the material or the length of the threads 75 and/or insert threads 76 can be chosen or not.

In such a way of proceeding, as described hereabove, it is then possible to use the specific gravity of the fibre layer 77 or respectively the batt 74 between 10 kg/m^3 and 80 kg/m^3 . This way, a weight per square meter of the fibre layer 77 of the batt 74,

for example at a thickness of approximately 5 mm, can be between 60 g/m^2 and 390 g/m^2, preferably 70 g/m^2.

Furthermore, it is advantageous if the fibres or threads 75 and/or insert threads 76 of the fibre layer 77 or respectively the batt 74 are strengthened before the connection with the core 4 of the structural member 1, for example by thermal cracking or respectively thermal binding because thereby an improved cohesion of the individual fibres or threads 75 and insert threads 76 can be achieved. Thereby it is advantageous if the individual fibres or respectively threads 75 and the insert threads 76 consist of thermoplastics. In particular thermoplastics are more likely to have a plasticizing point or respectively softening point of between 100°C and 200°C, preferably between 100°C and 120°C, which favour a thermal bonding of the individual fibres or respectively threads 75 and insert threads 76 or a thermal strengthening of the entire batt 74. Only during complete softening or plasticizing of tthe threads 75 during the forming on process to the core 4, the insert threads 76 are embedded in the liquid synthetic material and thus, are forming the supporting body 15 after the synthetic material has cooled. Moreover, it is advantageous if an adhesion of the thermoplastic synthetic material is not too strong and is between 5N/5 cm and 30N/5 cm for example.

Furthermore, it proved advantageous if the insert threads 76 of the supporting body 15 are formed as so-called long threads or respectively long-fibre insert threads 76, which may have a length between 20 mm and 80 mm. Theseindividual insert threads 76 can be formed of different materials such as glass and/or synthetic material and/or me-

tal and/or cermaics and/or graphite and/or natural fibres and/or kevlar, which, depending on the purpose of use can also be combined with one another. During the thermal treatment of the batt 74, these threads are also embedded in the synthetic material 17 of the layer 16, which is formed by the individual threads 75, and are at least partially enclosed by the latter which causes tthe development of the bearing element 19. During this thermal bonding process, the individual loose insert threads 76 of the supporting body 15 are connected with the layer 16 of synthetic material 17 in a fricational and/or formlocking manner.

FIG. 7 shows now the structural member 1, in which the bearing element 19 and also the bearing element 20 are formed by the batt 74 described in FIG. 6. The multi-layered structural member 1 shows again at least one of the two covering layers 2 and 3, whereby in this exemplary embodiment both layers are shown with the core 4 arranged therebetween.

The core 4 can be formed by flocks 5, 6, 7 which may consist of hard, semi-hard and/or soft foams, if required with laminates from different materials 8, 9 . These are connected by means of the foamed plastic 10, for example by polyurethane and/or polyethylene foam, polyether foam or the like, which may present a soft and/or semi-hard and /or a hard consistence, to the single plate 11. The core 4 can be formed for example of between 70% and 90%, preferably 85% of its volume by flocks 5, 6, 7 of foamed plastic 12, 13 and of 10% to 30% of the weight by the foamed plastic 10 of primary material. The flocks 5, 6,7 of foamed plastic 12, 13 may thereby present a specific gravi-

ty between 20 kg/m^3 and 250 kg/m^3, preferably 50 kg/m^3 to 150 kg/m^3. The specific gravity of the foamed plastic 10, which is preferably semi-stiff or semi-hard and is produced from primary material, is preferably between 800 kg/m^3 and 1 200 kg/m^3. The single plate 11 with a predetermined thickness 14 forms the core 4 and is preferably produced by cutting up a large-volume foamed block. However, it is also possible to use the single plate 11 which consists only of primary material of the foamed plastic 10, which can be formed as a hard, semi-hard or soft foam, or respectively instead of the flocks 5, 6, 7 of foamed plastic 12, 13 to use any othe rmaterial such as textiles, cork, wood, natural and/or synthetic substances. Furthermore, it is also possible to provide the flocks 5, 6, 7 from recycling or primary foamed plastic with coatings, in particular of textiles, leather, synthetic materials or imitation leather or respectively to back them with it.

In this exemplary embodiment the two covering layers 2, 3 of the structural member 1 are formed by the already thermally treated batt 74, which forms a frictional or formlocking connection between the core 4 and the top layer 18.

It is, of course also possible to produce the supporting body 15 from natural and/or synthetic materials, for example of a net, knitted fabric, fabric, braiding, lattice or batt of fibres or threads of glass, metal kevlar, graphite or textiles which are embedded in the layer 16 of thermoplastic synthetic material 17 and which are formed onto the core 4 by a thermal treatment.

Furthermore, as it is indicated schematically in the region of the covering

layer 2, it is also possible by means of the layer 16 of thermoplastic synthetic material 17, such as for example polypropylene, polyurethane, to form on simultaneously the top layer 18, for example, a material, knitted fabric, fabric, a carpet or a batt. As top layer 18 a wide variety of materials can be used. These are to be selected according to the field of use of the multi-layered structural member 1.

A particular advantage of a structural member 1 formed in such a way, lies however especially in the fact that at least one hard, and resistant covering layer 2 or respectively the bearing element 19 thereof, and, if required, the top layer 18 of the other covering layer 3 or respectively the bearing element 20 thereof or of a special top layer 21 is elastically damped and spaced apart by means of the flocks 5, 6, 7 of foamed plastic 12, 13, or respectively only by the primary foamed plastic 10 of the core 4. This way, these two covering layers 2, 3 can swing independtly of each other, and thereby a good noise damping can be achieved as it can be used particularly in the car industry or in case of room partition walls ot the like with the particular advantage for structure-borne noise damping.

The advantage lies in particular in the fact that by using the layer 16 of thermoplastic synthetic material 17 and which is reinforced with the supporting body 15, a high surface and edge presuure strength can be achieved for the resistanbt covering layers 2, 3, and on the other hand, the total weight of such structural members 1 can be kept at a minimum by the low specific gravity of the core 4.

Different production steps can be selected for the production of the structural member 1. Thus, it is for example possible to produce finished parts on the one hand, and semi-finished parts on the other hand. When producing finished parts at least one covering layer 2, 3 with the associated top layer 18, 21 is formed onto the core 4 in one continuous processing step. Thereby a tight connection is chieved between the surfaces of the core and the individual top layers 18, 21 by means of the bearing elements 19, 20. In this production process it is of course possible to give the structural member 1 the required spatial shape and eventually to compress the core 4 at least in certain regions.

In order to stabilize the desired spatial shape of structural member 1 produced in such a manner, it is cooled either directly in the form tool or in a cooling tool provided particularly for this matter according to its shape so as to stabilize it in this spatial form or to strengthen it, i.e. to "freeze" the synthetic material, after the bonding process which accurs under the above described temperatures.

Furthermore, it is also possible to produce a so-called semi-finished part which consists merely of the core 4 and of a bearing element 19, 20 which is arranged at least on one surface of the core 4. This semi-finished part can be formed as a web-shaped element or a plate. The semi-finished part can be heated thereafter to be used in a heating staation for example, so that the synthetic material 17 of the bearing elements 19, 20 is softened or respectively liquefied, however, at least is heated up to such a degree that it becomes sticky on its surface. This heating can take place before a top layer 18, 21 is applied to at least one surface of the bearing element 19, 20 or after this top layer 18, 21

has been applied.

Care must be taken during the heating of this semi-finished part that the semi-finished part is clamped with or without the covering layer, which has been inserted already, according to the prefabricated spatial shape, or respectively into this prefabricated form, or respectively that an extension beyond the prefabricated measures is prevented by a corresponding counter pressure. This is possible because when the semi-finished part is re-heated, an expansion of the air and additional exhalation of chemical components takes place in the cells and cavities of the semi-finished part, in particular the foamed plastic or respectively synthetic material, which try to blow up the semi-finished part when these gases cannot pass through into the outside because of the closed cells or through the two bearing elements 19, 20. To ensure dimensional stability during the heating process, it is necessary to keep the semi-finished parts in the desired spatial shape.

Of course, the heated semi-finished product can be brought, for example also after an intermediate insertion of a required top layer 18, 21 into any spatial form with the bearing elements 19, 20 and also the top layers 18, 21, and can be strengthened by cooling in said form.

Thus it is possible in a simple manner to produce the structural member 1 as a finished product or finished part and on the other hand also to produce semi-finished parts or semi-finished products for storage, which can be coated thereafter with the desirerd top layer 18, 21 according to the wishes of clients.

Merely for good order's sake it should be finally indicated that for improved understanding of the invention the individual parts of the devices 40 or respectively the structural member 1 and the layers thereof have been presented in a distorted manner, unproportionally and untrue to scale. The same applies for the selected thickness, width and lengths ratios of the individual layers, in particular of the supporting body 15 and the layers of thermoplastic synthetic material 17.

Moreover, each exemplary embodiment can also form its own solution in accordance with the invention, and likewise, individual or any combinations of the claims may form their own solutions in accordance with the invention, and also individual features of the embodiments, if required, in any combination of different exemplary embodiments.

In particular, the individual embodiments shown in FIGS. 1, 2; 3; 4; 5; 6, 7 can form the object of own solutions in accordance with the invention. Relating tasks and solutions are apparent from the detailed descriptions of these figures.

WHAT IS CLAIMED IS:

1. Multi-layered structural member comprising a core of a foamed plastic of primary material and if required, of flocks of foamed plastic connected therewith, and at least one covering layer having a supporting body of fibres or respectively threads, arranged on a surface of the core and connected with the latter in a frictional and formlocking manner, characterized in that the fibres or respectively threads of the supporting body (15) are embedded in a layer (16) of thermoplastic synthetic material (17) forming the covering layer (2,3), and that by means of the latter they are at least formed onto the core (4) and connected thereto in a frictional or respectively formlocking manner.

2. Multi-layered structural member according to Claim 1, characterized in that the core (4) is formed by flocks (5, 6, 7) of recycling or respectively primary foamed plastic, in particular of hard or respectively semi-hard and/or soft foams.

3. Multi-layered structural member according to Claim 1 or 2, characterized in that the flocks (5, 6, 7) of recycling or respectively primary foamed plastic are provided with coatings, in particular of textiles, leather, synthetic material or imitation leather or respectively are backed therewith.

4. Multi-layered structural member according to Claim 1 or 3, characterized in that the core (4) between 70% and 95%, preferably 85% consists of flocks (5, 6, 7) of foamed plastic (12, 13).

5. Multi-layered structural member according to Claim 1 or 4, characterized in that 10% to 20% of the weight of the core (4) are formed by a foamed plastic (10) of primary materials, for example polyurethane.

6. Multi-layered structural member according to one or more of Claims 1 to 5, characterized in that the specific gravity of the recycled foamed plastic added to the core (4) is between 20 kg/m^3 and 250 kg/m^3, preferably 50 kg/m^3 and 150 kg/m^3.

7. Multi-layered structural member according to one or more of Claims 1 to 6, characterized in that the specific gravity of the foamed plastic (10) of primary material is between 800 kg/m^3 and 1 200 kg/m^3, preferably 1 000 kg/m^3.

8. Multi-layered structural member according to one or more of Claims 1 to 7, characterized in that the foamed plastic (10) of primary material is semi-stiff or respectively semi-hard.

9. Multi-layered structural member according to one or more of Claims 1 to 8, characterized in that the layer (16) of thermoplastic synthetic material (17) consists of polyethylene, polyamide, polypropylene, polystyrene, PVC, polyimide, ABS or the like.

10. Multi-layered structural member according to one or more of Claims 1 to 9, characterized in that the supporting body (15) is formed by a net and/or

knitted fabric and/or batt of different fibres or respectively insert threads (76) of glass and/or metal and/or kevlar and/or graphite and/or textiles and/or synthetic material and/or ceramics and/or natural fibres and/or carbon.

11. Multi-layered structural member according to one or more of Claims 1 to 10, characterized in that the fibres or respectively insert threads (76) of the supporting body (15) are of glass and/or metal and/or kevlar and/or graphite and/or textiles and/or synthetic material and/or ceramics and/or natural fibres and/or carbon.

12. Multi-layered structural member according to one or more of Claims 1 to 11, characterized in that the supporting body (15) is coated or respectively filled with a granulate, for example a powder or a foil of the thermoplastic synthetic material (17) having a hard consistence.

13. Multi-layered structural member according to one or more of Claims 1 to 12, characterized in that the supporting body (15) is coated with a paste of the thermoplastic synthetic material (17), which adheres only slightly at room temperature.

14. Multi-layered structural member according to one or more of Claims 1 to 13, characterized in that the supporting body (15) consists of polyurethane.

15. Multi-layered structural member according to one or more of Claims 1 to 14, characterized in that the thermoplastic synthetic material (17) is at least

viscous under pressure and a temperature between 120°C and 180°C.

16. Multi-layered structural member according to one or more of Claims 1 to 15, characterized in that the thermoplastic synthetic material (17) is liquid at a temperature between 150°C and 200°C and/or that there is very little adhesion, for example between 5 and 30 N/5cm.

17. Multi-layered structural member according to one or more of Claims 1 to 16, characterized in that on the supporting body (15) a top layer (18) is formed on, in particular a knitted fabric, fabric, a batt or a foil of natural and/or synthetic materials and that it is formed onto or adheres to the supporting body (15) by means of the layer (16) of the thermoplastic synthetic material (17).

18. Multi-layered structural member according to one or more of Claims 1 to 17, characterized in that in the core (4) which consists preferably of several plates, or respectively between the core (4) and a surface of the bearing element (19, 20) facing awayfrom the core (4), a reinforcement element (32) is arranged.

19. Multi-layered structural member according to one or more of Claims 1 to 18, characterized in that between the supporting body (15) of a bearing element (19, 20) and a top layer (18, 21), a reinforcement element (32) is arranged or preferably embedded in the layer (16) of the thermoplastic synthetic material (17).

20. Multi-layered structural member according to one or more of Claims 1 to 19, characterized in that the bearing element (19, 20) is formed as a batt (74).

21. Multi-layered structural member according to one or more of Claims 1 to 20, characterized in that the batt (74) is formed by an entanglement of threads (75) and/or insert threads (76) or respectively fibres.

22. Multi-layered structural member according to one or more of Claims 1 to 21, characterized in that the threads (75) are formed by thermoplastics, in particular polypropylene and/or polyamide and/or aromatic amide and/or polyester and/or PVC and/or ABS and/or polyimide and/or polystyrene and have a length of between 5 mm and 50 mm.

23. Multi-layered structural member according to one or more of Claims 1 to 22, characterized in that the insert threads (76) or respectively fibres are embedded in the synthetic material (17) of the layer (16) and are forming the supporting body (15) and have also a length between 20 mm and 80 mm.

24. Method for the production of a multi-ayered structural member wherein flocks of a foamed plastic are mixed with a liquid primary material of a foamed plastic and are formed into a plate or respectively a block, which under the actrion of pressure and/or temperature and/or moisture is brought to react and that the flocks of foamed plastic are interconnected by means of the plastic foam of primary material,

whereupon at least on one surface of such a plate or block, a covering layer is applied, and under the effect of pressure and/or temperature, if necessary, spatial deformation, the covering layer is connected with the plate or respectively block to a multi-layered structural member, characterized in that before the covering layer is applied on the plate or respectively block of the covering layer, a granulate and/or a foil and/or a paste of a thermoplastic synthetic material is applied onto a fibre-shaped or thread-shaped supporting body of the latter, whereupon thereafter the covering layer with the htermoplastic synthetic material is heated to such a degree that it becomes vscuous, whereupon the covering layer is put onto the plate or block which forms a core of the multi-layered structural member and is pressed into the latter to displace the thermoplastic synthetic material into the surface regions of the core, and that immediately thereafter the covering layer is cooled and after a sufficient solidification and/or after falling short of the temperature of the freezing or flow point of the thermoplastic synthetic material, the structural member is taken out of the mould.

25. Method according to Claim 24, characterized in that the covering layer and/or the core is spatially deformed simultaneously when the thermoplastic synthetic material is pressed into the surface regions of the core.

26. Method according to Claim 24 or 25, characterized in that the core is heated before or during the spatial deformation of the covering layers and the core.

27. Method according to one or more of Claims 24 to 26, characterized

in that simultaneously with the spatial deformation of the covering layer, the cell structure of the core is thermally cracked und fixed in the deformed position.

28. Method according to one or more of Claims 24 to 27, characterized in that the thermoplastic synthetic material is heated to a temperature between 120 °C and 180 °C.

29. Method according to one or more of Claims 24 to 28, characterized in that the multi-layered structural member at least in the surface regions, is heated to a temperature between 150°C and 200°C whereupon the covering layer is pulled off the core.

30. Method according to one or more of Claims 24 to 29, characterized in that the thermoplastic synthetic material in the bearing element is heated to a temperature of above 200°C and is removed, in particular sucked of, in a liquid state from the fibre-shaped or respectively thread-shaped supporting body.

31. Method according to one or more of Claims 24 to 30, characterized in that before the covering layer is pressed onto the core between the covering layer and the pressing tool, a covering layer is inserted and the latter by means of the thermoplastic synthetic material which impregnates the covering layer, is connected immovably to, or connected to each other or formed on one another, with the covering layer or respectively the core for a mutual movement.

32. Device for the production of a multi-layered structural member comprising a core of flocks of foamed plastic interconnected by a foamed plastic of primary material and two covering layers arranged on opposite surfaces of the core and connected with the latter in a frictional and/or formlocking manner, with a fibre-shaped or respectively thread-shaped supporting body with a conveying device for the supporting body which is coated with thermoplastic synthetic material or respectively impregnated therewith, which granulates at room temperature, and is presented in the form of a foil or slightly adhesive paste, characterized in that the conveying device of two transportation walls which are parallel to one another and running one above the other spaced apart by an adjustable distance, in particular formed of Teflon, and which are associated with a heating device at least over a portion of their length, and that a compression mould is arranged downstream of this conveying device, and that between the conveying device and the compression device, a handling device is arranged for the supporting body of the covering layer, which is impregnated with the layer of thermoplastic synthetic material and/or the core which consists of foamed plastic.

33. Device for the production of a multi-layered structural member according to Claim 32, characterized in that at least one of the two mould halves is provided with holding devices, in particular vacuum slots in order to receive and hold a top layer.

Fig.1

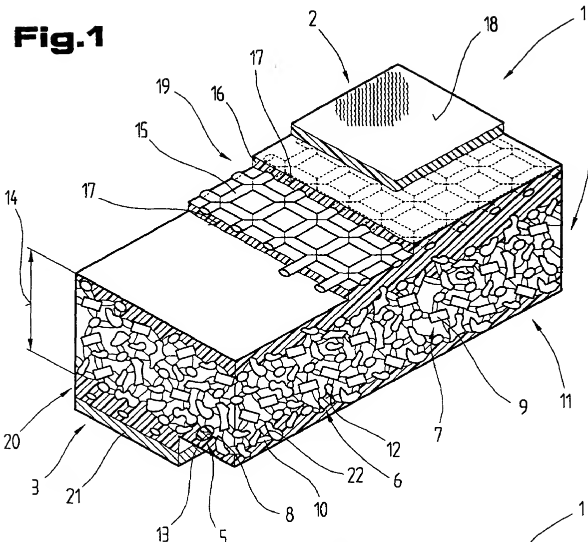
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Fig.2

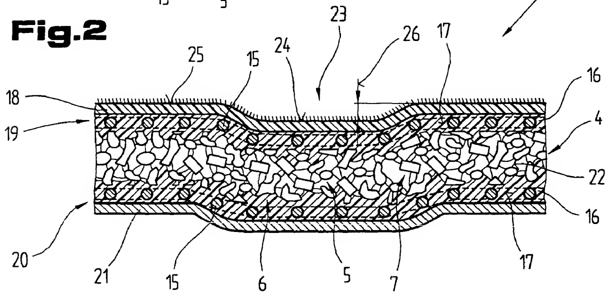
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Fig.3

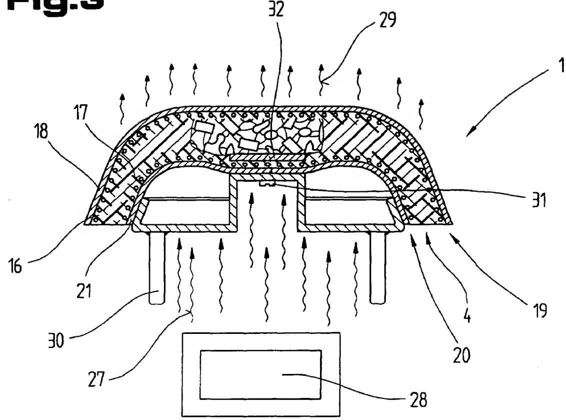

Fig.4

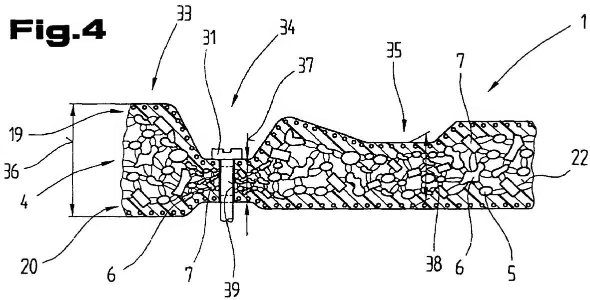

Fig.5

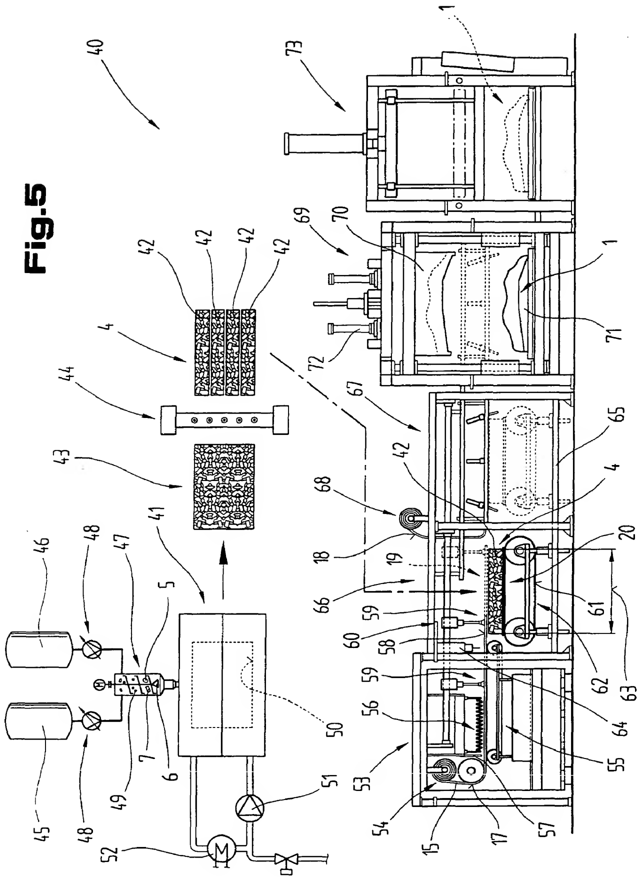

Fig.6

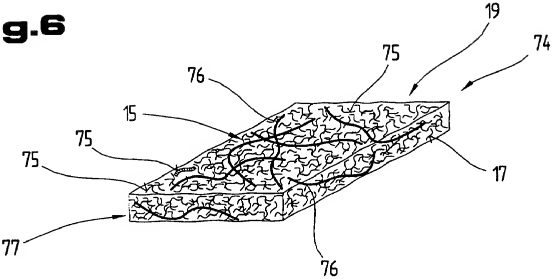
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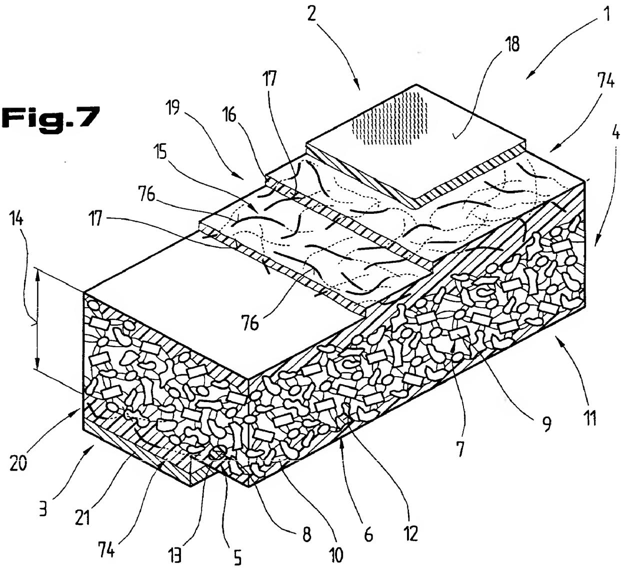
Fig.7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